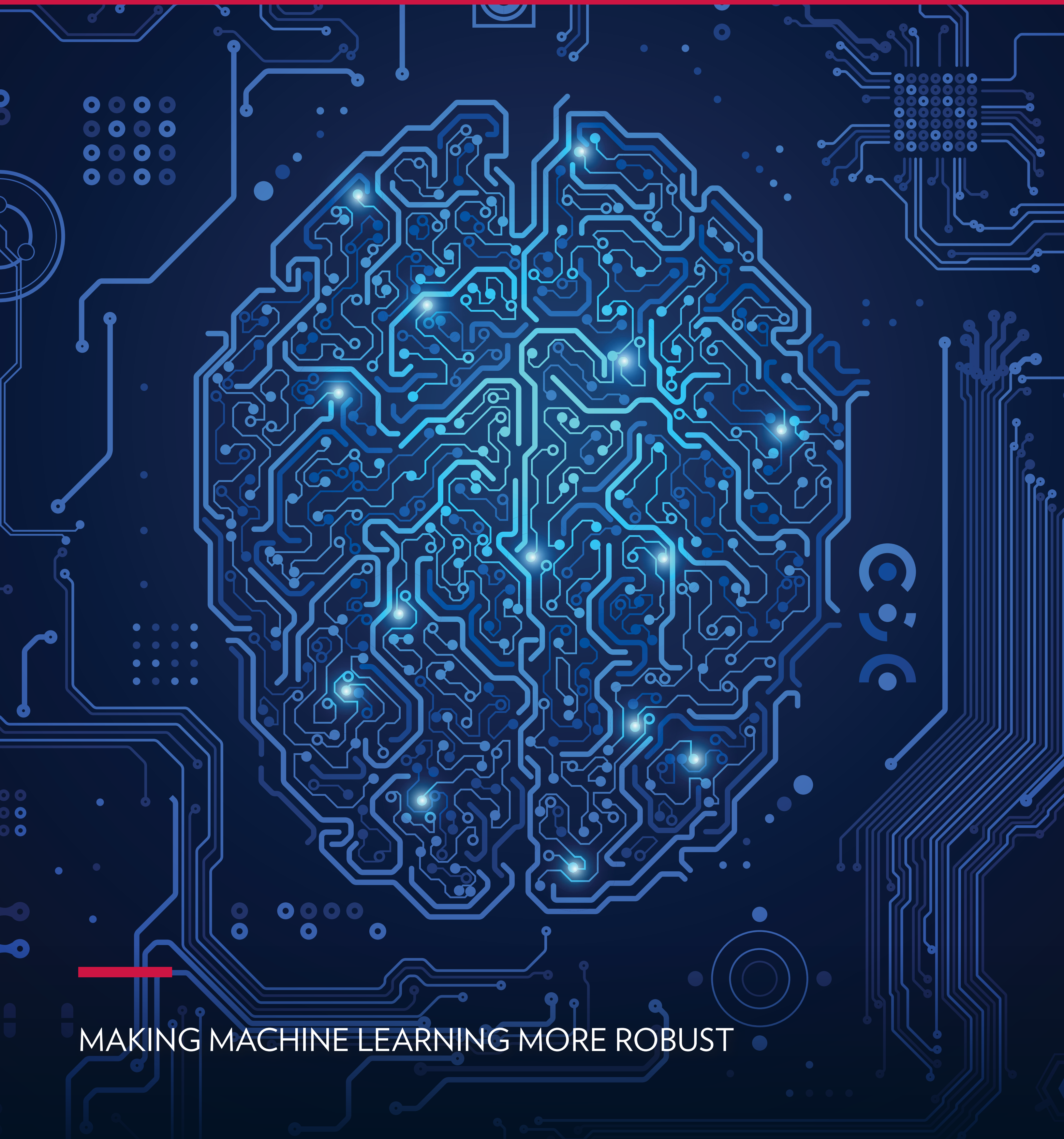
SPRING/SUMMER 2019

ELECTRICAL AND COMPUTER ENGINEERING

UNIVERSITY OF WISCONSIN-MADISON



MAKING MACHINE LEARNING MORE ROBUST

CHAIR'S MESSAGE

Hello from Madison!

It's my distinct pleasure to reflect upon the many milestones, awards and accomplishments that our department has seen in recent months as my first full year as department chair draws to a close. I hope you'll join me in feeling pride as you read this issue for being a member of the UW-Madison ECE community, and know that you are part of a long tradition of excellence.

Firstly, please join me in congratulating Assistant Professors Dimitris Papailiopoulos, Younghyun Kim, and Andreas Velten for earning prestigious CAREER awards from the National Science Foundation. You can read about Dimitris's research project, which leverages coding theory for large-scale machine learning, within this newsletter. We'll highlight Younghun's and Andreas's NSF-funded projects in our next newsletter.

Dimitris, Younghyun, and Andreas are three of our outstanding assistant professors in ECE, all of whom have been earning recognition as rising stars in the community. That's not to discount the contributions of our more senior faculty, though. Thanks to my predecessor, John Booske's tireless efforts, our education program was recently honored for its innovation by the national association of ECE department heads. Additionally, Professor Amy Wendt, was tapped by the National Academies to help chart the course for the future for burning plasma research in the United States as a means for addressing our nation's future energy needs.

Such faculty leadership at the national level is but one variable in the multicomponent expression that describes ECE at Wisconsin. Our students and alumni form the heart and soul of our department, and we could not be more proud of the work they do. You can learn about some of the award-winning research from our current students—on topics ranging from healthcare ID bracelets to traffic-alerting RFID tags in smart cities—as well as our amazing alumni inside these pages.

We're also excited at the steady growth of the recently established one-year accelerated master's program in signal processing and machine learning. The program graduated its first three students in August, 2018. As we enter our third year, we have an incoming class of 23 new students for this fall! We're thrilled to offer this innovative option for students to obtain essential skills and knowledge for the 21st century workforce.

Finally, this spring was the first ever Day of the Badger, an event for all alumni, students, and friends throughout Badger nation to give to their passion, show their pride, and stay connected to the university. During the 1848-minute experience that began on Monday, April 8, at 5 p.m. and concluded on Tuesday, April 9, at midnight, the College of Engineering received $1,863,080 in donations. It's a point of pride that ECE was the top department, with donations totaling roughly $14,800. Thank you so much to everyone who made Day of the Badger such a smashing success, and be on the lookout for next year's event!

Looking ahead, we're excited for new faculty to join our department this upcoming fall. It has been an extraordinarily busy spring interviewing faculty candidates, and I know our new hires will reinforce ECE's traditional areas of strength and add their diverse new perspectives to the department. Watch for news about the new faculty in future newsletters.

I wish you all a wonderful summer, and I urge you to reach out at any time, whether to arrange a visit to campus or just to say, hi!

ON, WISCONSIN!

Susan Hagness, Philip Dunham Reed Professor and Chair
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PAPAILIOPOULOS EARNS NSF CAREER AWARD

What cell phone clarity can teach machine learning

Among a growing list of everyday uses, machine learning powers the silicon brains behind digital assistants like Apple's Siri or Amazon's Alexa, and allows intelligent control systems to steer self-driving cars.

But even though machine learning solutions have become incredibly smart in recent years, the predictive models and algorithms that support them still have some issues with robustness—in other words, the ability to return a correct answer when faced with noisy, or murky, information.

It's an important problem, because the real world is an inherently noisy place. So in machine learning, a lack of robustness could, for example, cause a self-driving car to miss a stop sign if the sign appears different from what's "normal"—perhaps someone has placed a sticker on the red octagonal face.

> **"We're finding that coding theory can be better than the current state-of-the-art solutions for robustness."**
>
> **— Dimitris Papailiopoulos**

"For applications that involve human lives, you want to be very confident in the decisions these predictive models make," says Assistant Professor Dimitris Papailiopoulos.

Papailiopoulos is taking an unconventional approach to make machine learning algorithms and models more robust by drawing from the field that helps our cell phone conversations come through without being garbled. That's an area called coding theory.

"We're finding that coding theory can be better than the current state-of-the-art solutions for robustness," says Papailiopoulos. "It can give us a significant jump in performance."

It's a strategy that earned Papailiopoulos a prestigious CAREER Award in 2019 from the National Science Foundation.

Making machines intelligent

Like methods that drive human learning, machine learning models get smarter through a process called training, during which these models parse vast catalogs of well-labeled data.

Crucially, machine learning algorithms develop the "rules" that allow predictive models to classify objects without any human input. That means the key features and patterns that an algorithm uses to distinguish a cat from a tree from a stop sign can be completely different from the obvious features that a human might observe.

Training also takes time and substantial computational resources—so to speed things up, programmers often run these algorithms in parallel on several hundred processing units at once.

But parallel computing isn't perfect, either: Sometimes one or two of the units will lag behind the others, or crash, or return some other unexpected error, losing information and compromising the algorithm's robustness.

Adding encoded info

That's where coding theory comes in. Almost all modern devices that store or transmit information make use of coding theory. However, Papailiopoulos is among the first researchers to apply these techniques to machine learning algorithms.

"Coding theory is the best way we have to ensure robustness in the face of uncertainty," he says. "The big difference is that machine learning is not just bits being stored, it's an algorithm that acts on your data."

Cell phones use coding theory to prevent snippets of conversation from becoming lost. CDs deploy the same techniques to play music from a scratched disc. It's the field that allows us to reconstruct a complete parcel of data even when some of the individual bits go missing.

The simplest strategy to prevent data loss is replication—sending the same message 1,000 times as insurance against the 10 percent of instances where a bit will be lost. But rampant replication wastes resources, so coding theory has developed methods for sending and storing encoded versions of the information. That can correct for more errors at lower computational cost.

Similarly, coding theory can offer a path toward robustness for machine learning. If one of the computational nodes lags behind during model training, coding theory can prevent information loss.

"Instead of encoding bits, we'll encode algorithmic outputs," says Papailiopoulos.

But Papailiopoulos isn't only focused on the training aspect of machine learning. He also plans to tackle the far-more difficult task of ensuring robustness when these predictive algorithms function in the real world.

Ensuring real-world accuracy

Machine learning algorithms learn in a "perfect" world: They're fed a careful diet of well-labeled datasets that enable them to develop classification rules. But the real world is not perfect, which is why algorithms can get thrown off by something as simple as a stop sign that's slightly askew.

"The signal that comes from the world is completely uncurated," says Papailiopoulos. "You can't control in real time the images that are received by an autonomous vehicle."

Ensuring robustness is an ongoing challenge for the entire machine learning field—but it might be possible to strategically include the types of images that are most likely to trip up machine learning algorithms in initial training sets. That's something that Papailiopoulos is actively pursuing.

"That's why this is interesting," he says. "Being sure that things that are deployed in practice, will do not just what they are prescribed to do, but also that the models will work in a safe way."

WATCH OUT!

Using wearables and smartphones to prevent traffic accidents

Photo: Jeff Miller

In urban and suburban areas alike, it's an all-too-familiar accident scenario: Cars zipping along a road; suddenly, a pedestrian or bicyclist veers into traffic.

In the future, a warning system could alert drivers before a collision occurs between vehicles and walkers or cyclists.

An ambitious new project led by Assistant Professor Kassem Fawaz aims to create such an alert system. With a $924,000 grant from the U.S. Department of Transportation's Federal Highway Administration, he and his collaborators are leveraging the power of mobile computing to make the streets safer for everyone.

"The core idea is relying on devices that people already use, like smartphones or wearables, to monitor their mobility and to predict when there could be a potential conflict with other road users," says Fawaz.

The researchers plan to create an app that gathers GPS location and motion data from the accelerometers and sensors already present in most people's cell phones or smartwatches, and then leverage the power of machine learning algorithms to identify subtle movement signatures that predict unexpected pedestrian or cyclist actions such as jaywalking or swerving across traffic.

When the app anticipates a potential conflict, it will send out messages to nearby drivers, warning them to be extra-cautious—especially on stretches of road between traffic lights and crosswalks. A gentle notification could remind drivers to keep their eyes open, and might help prevent some of the more than 5,000 pedestrian deaths that occur every year in the United States.

"Most of these accidents don't happen at intersections," says Fawaz. "People are less attentive when they're just driving down the street."

Crucially, the system won't require any new hardware or infrastructure; all the analysis and messaging will occur on people's own devices.

"The core idea is relying on devices that people already use, like smartphones or wearables, to monitor their mobility and to predict when there could be a potential conflict with other road users." — Kassem Fawaz

And in case people might feel squeamish about an app that tracks their movements, the scientists are building strict privacy protections into the system.

"All of the processing will stay on the device," says Fawaz, "There's no server that will collect your data."

Security also is a primary concern, and the scientists are incorporating strategies to ensure that bad actors won't be able to jam up the system by sending fake messages, which could snarl traffic.

Fawaz and colleagues plan to demonstrate a test of the platform on the roads of Madison within three years.

His UW-Madison collaborators include ECE Professor Parmesh Ramanathan, and Civil and Environmental Engineering Associate Professor Soyoung Ahn, Assistant Scientists Madhav Chitturi and Arthur F. Hawnn, and Professor David Noyce.

Yuchen Gu, a senior majoring in electrical engineering, advanced to the second round of the Foxconn Technology Group's Smart Cities—Smart Futures competition. The contest sought innovative ideas to enhance quality of life, improve working environments, expand transportation networks and living spaces, inspire creative city planning, and promote sustainable energy solutions in Wisconsin. Gu's winning concept proposed a smart traffic alerting system that integrates RFID tags and vehicle-to-infrastructure technology to provide an extra layer of protection for vulnerable groups such as teenagers and bikers. As a first-round winner, Gu received $500 to help develop his project.

How smart ID bracelets could improve healthcare

Bahar Behzadenzhad

Setareh Behroozi

With a bit of an upgrade, the barcoded ID wristbands that identify patients throughout their hospital stays could become powerful tools for improving their treatment outcomes—while at the same time, slashing healthcare costs.

It's an idea that earned **Bahar Behzadenzhad** and **Setareh Behroozi**—both ECE PhD students—the final-round prize and a total of $7,000 in the 2019 Foxconn Smart Cities Smart Futures Competition.

"I work in the hospital. I see patients with barcode wristbands every day," says Behzadenzhad. "We saw an opportunity to use Bluetooth technology for real-time patient monitoring and information transfer."

Their concept hinges on embedding low cost and MRI-safe Bluetooth transceivers into the wristbands people already receive on hospital check-in.

It's a project that draws upon the students' expertise: Behzadenzhad researches antenna technology for MRI scanners, while Behroozi studies low-power systems for wearable and implantable devices.

Their smart wristbands could not only allow doctors to call up decades of medical records at a moment's notice, but they also could help track patient progress through the healthcare system—and thus, provide a treasure trove of information to help hospitals operate more efficiently.

"Effective smart tracking is a brilliant example of how Bluetooth and the internet of things can combine to improve healthcare and patient security," says Behzadenzhad. "Knowing where your patient is at all times can dramatically improve treatment."

Bluetooth tracking also could, for example, offer peace of mind for the family members of elderly patients, minors or people with dementia—or tell care staff whether their patients have arrived on schedule to an exam room, or not.

"Sometimes treatments aren't effective because patients forget about their appointments, get lost in the hospital, or take their medicine at the wrong time," says Behroozi.

In the longer term, hospitals could analyze data about how patients move through their corridors, enabling the facilities to optimize staffing and resource allocation, improve layouts and eliminate inefficiencies—potentially in real time.

All of this is a wealth of data that, as of now, is largely untapped.

"There are already many companies that sell staff optimization or schedule optimization to hospitals," says Behroozi, "But they don't have the information or the data to back up the decisions."

Currently, the students are working on incorporating privacy safeguards into their product to ensure patients' information is secure.

They're also continuing to conduct market research, and they've been getting an enthusiastic reception from medical professionals.

"There are many inefficiencies in hospitals," says Behzadenzhad. "I see it every day and I hear about it from MRI technicians. It would be a huge thing if you could make those decisions with smarter data."

Andy Schroedermeier, a PhD student advised by Assistant Professor and Dugald C. Jackson Faculty Scholar Dan Ludois, won a poster presentation award at the 2018 IEEE Applied Power Electronics Conference and Exposition (APEC). Schroedermeier's research focuses on electric motors with an emphasis on passive components to alleviate some of the problems that arise with variable speed drives. The paper associated with the award-winning poster was titled "Integrated inductors, capacitors, and damping in bus bars for *dv/dt* filter applications." Based on that research, Schroedermeier recently launched an online tool for calculating whether a power electronic device will need filters applied between the drive and the motor. Access the tool at dvdtfilter.com.

Privacy-protecting cameras earn prize

Smart cameras help us care for our homes, pets and loved ones, but what's looking out for our privacy beneath the gaze of so many artificial eyes?

"There's a huge amount of data being uploaded to the cloud," says **Jingjie Li**, a second-year ECE PhD student. "We want to ensure that private data can be protected at the user end instead of being uploaded."

That's why Li and fellow graduate students **Setareh Behroozi**, **Tianen Chen**, **Di Wu** and **Zongshen Wu**, all in the electrical and computer engineering department, developed a concept called Nightshift, which would empower smart cameras to preserve people's anonymity.

Nightshift was another winner in the final round of Foxconn Technology Group's inaugural "Smart Cities-Smart Futures" competition.

The students will use the prize as seed money to push forward with algorithm development for their product.

Clarivate Analytics has named Assistant Professor **Mikhail Kats** a 2018 highly cited researcher. Kats' cross-disciplinary research draws from optics, photonics, device physics and nanotechnology, and his papers have accumulated more than 9,000 citations on Google Scholar since 2013. The highly cited researcher distinction reflects that Kats' papers were among the top 1-percent most-cited manuscripts by his peers.

Patricia and Michael Splinter Professor **Irena Knezevic** was honored as an outstanding referee by the American Physical Society. The distinction is bestowed by the editors of the APS family journals onto the best reviewers among the more than 71,000 practicing scientists who evaluate manuscripts prior to publication. Peer reviewers are uncompensated and anonymous, yet essential to maintaining the integrity of the published literature. Knezevic's insightful critiques and adherence to deadlines have been invaluable to editors, earning her high praise.

Assistant Professor **Dimitris Papailiopoulos** received the Benjamin Smith Reynolds Award for Excellence in Teaching from the College of Engineering for his significant contributions as an educator and determined advocacy for pedagogical best practices. Papailiopoulos consistently rates among the best instructors in ECE from undergraduate evaluations in his large-enrollment courses. He also developed a new graduate level course that met an important need in the data sciences area and now fills an important role in the department's accelerated master's degree program in signal processing and machine learning. Passionate about educational innovation, he is currently transforming another undergraduate course to incorporate active learning and explore probability and random signals concepts from a data science perspective. Since joining the ECE faculty, he has become an educational leader, inspiring others through his example.

In recognition of his pioneering research on high-efficiency and high-power-density new and classical electric motors with wide bandgap device power electronic drives, Associate Professor **Bulent Sarlioglu** received the highly prestigious Grand Nagamori Award. Established in 2015, the award highlights innovative developments to raise awareness of the vital importance of motor technology in today's modern industrial economy as part of the Nagamori Foundation's ongoing efforts to promote research related to motors, actuators and power generators in order to address the challenges of creating affluent lives and perpetually conserving the global environment. At the recognition ceremony in Kyoto on Sept. 2, 2018, Sarlioglu received the award from Shigenobu Nagamori, the founder and CEO of Nidec Corp., a leading comprehensive motor manufacturer. The event recognized six researchers in total with certificates of achievement, yet Sarlioglu was selected for special distinction and honor with the Grand Nagamori Award.

Professor **Giri Venkataramanan** and Kyle Hanson, lab manager for the Wisconsin Electric Machines and Power Electronics Consortium, served as general co-chairs for the IEEE International Future Energy Challenge, which will hold its final round of competition on the UW-Madison campus July 29-31, 2019. The contest is an international student competition for innovation, conservation and effective use of electrical energy, and during the event, teams from around the world will present their concepts for E-drive bicycles. Also on the steering committee is Associate Professor Bulent Sarlioglu.

Professor **Amy Wendt** coauthored a report from the National Academies of Sciences Engineering and Medicine that urges the United States to develop plans to benefit from its investment in burning plasma research and take steps to develop fusion electricity for the nation's future energy needs. Wendt is a leading expert in burning plasma research, which is one reason she was tapped to steer our nation's agenda in the field. This latest report recommends that the United States remain a partner in ITER, a multinational facility located in Europe, while starting a national program to construct a compact pilot plant that produces electricity from fusion at the lowest possible capital cost.

The Institute of Electrical and Electronics Engineers (IEEE) selected two UW-Madison electrical and computer engineering faculty members for prestigious appointments as distinguished lecturers. The honor provides opportunities for researchers at the tops of their disciplines to travel and give presentations at IEEE chapter events, facilitating discussions between the best scientists and industrial experts to move their fields forward.

Susan Hagness, the Philip Dunham Reed Professor and department chair, was appointed for 2018-2020 by the IEEE Antennas and Propagation Society. Hagness' research focuses on applied electromagnetics including the development of microwave-frequency diagnostic and therapeutic technologies for biomedical applications.

The IEEE Industry Applications Society named **Bulent Sarlioglu** as a distinguished lecturer for 2019-2020. His areas of expertise include electric machines and wide bandgap device-based power electronic converters for hybrid and electric vehicles, electric aircraft and ships, wind and solar power generation and industrial applications.

A BRIGHT IDEA LEADS TO MORE EFFICIENT LASERS

Dan Botez

Luke Mawst

Imagine a sensor that detects trace amounts of dangerous chemicals or explosives from afar—something that could "sniff out" a bomb or poison gas from hundreds of yards away.

Such advanced sensors require high-powered lasers. And the future looks bright, as engineers in ECE have developed some of the world's most efficient technology for high-powered devices called quantum cascade lasers.

"The future, when this becomes practical, is that you can sense everything, you can detect everything," says Philip Dunham Reed Professor Dan Botez.

Quantum cascade lasers could point the way to advanced sensors because they emit beams of light at wavelengths for which light is not absorbed in the atmosphere. That range, which is called the mid-infrared, also happens to be the signature spectrum for many common explosives and toxic chemicals. In contrast, the diode lasers found in DVD players or supermarket scanners cannot operate in the mid-infrared range.

"With these advanced structures, where you can vary every layer, you can get close to the maximum possible internal efficiency." — Dan Botez

The main difference between quantum cascade lasers and diode lasers is the nature of the light-emitting material that forms the basis for each their beams.

Diode lasers usually consist of stacks of material made from between five and 10 relatively thick layers. When current flows through the stack, the material's electrons become excited and they "jump" up to a higher-energy region, or band. When those electrons fall back down into the band from which they came, the material emits light. Because the jump between energy bands is relatively large, diode lasers give off higher-energy, shorter wavelength light.

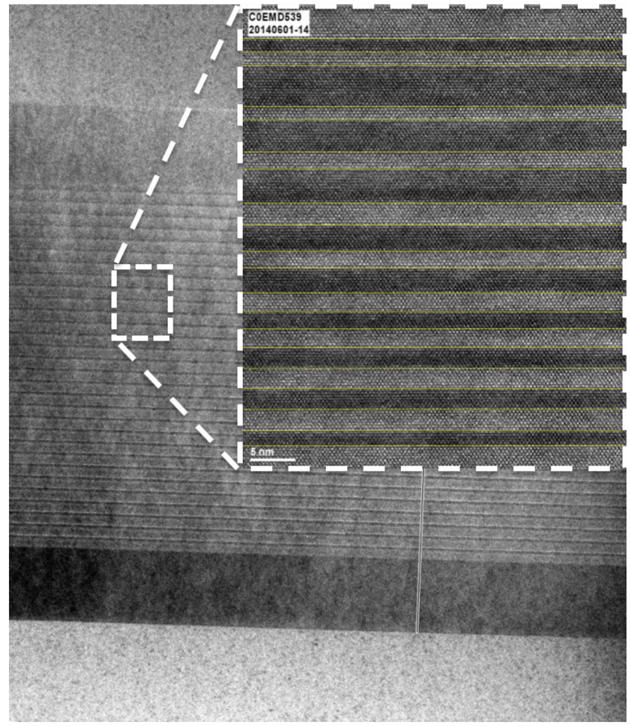
Quantum cascade lasers are capable of emitting longer-wavelength mid-infrared light because their composition allows electrons to transition between more narrowly separated discrete energy levels within a band. That's because quantum cascade lasers are made up of hundreds of very thin layers.

However, today's quantum cascade lasers have relatively low-powered beams—limiting their usefulness for long-range sensing. And with all those layers, another downside is low overall device efficiency; current technologies convert, at most, 10 to 20 percent of the electricity that they receive into light.

That low efficiency is a big problem, because most of the electricity not converted into light becomes heat, which must be removed, adding bulk and cost to devices. What's more, excess heat limits the useful lifetime of lasers, "frying" their components from the inside out.

To address these issues, the UW-Madison researchers, including Professor Luke Mawst, took advantage of a materials growth technique called metal organic chemical vapor deposition, which allowed them to lay down very thin layers while engineering precisely designed wells and barriers into strategic locations along the stack. The method also allowed them to vary the composition of each layer at will.

"We have unique facilities for fabrication, expertise in device design, and we can take advantage of UW-Madison's strength in materials characterization," says Mawst. "We have the complete toolset we need to push these things to the performance limit."



Delicate layers of custom materials create some of the world's most efficient and high-powered quantum cascade lasers.

That toolset allowed them to achieve a record-breaking 86-percent internal efficiency of converting electrons to photons. This will allow them to soon reach electricity-to-light efficiency in excess of 40 percent.

"At first people didn't believe it was possible," says Botez. "With these advanced structures, where you can vary every layer, you can get close to the maximum possible internal efficiency."

The researchers are currently working on strategies to improve the beam quality for the lasers. They have licensed the technology through their spinoff company, Intraband LLC.

ELUSIVE DIAMOND TRANSISTORS COULD SPARK MULTIFACETED ELECTRONICS PERFORMANCE GAINS

Diamonds, it turns out, can be an electrical engineer's best friend.

And with a little polish, a multi-university team of researchers plans to use diamond to create high-power communication devices that can transmit signals with higher dynamic ranges than any other existing technologies.

It's a project they hope will lead to more than four-fold improvements in state-of-the-art bipolar transistors—a technology for enhancing the nation's military capability that could also improve our cell phones, home appliances and the power grid.

Led by Professor Zhenqiang (Jack) Ma, the Lynn H. Matthias Professor in Engineering & Vilas Distinguished Achievement Professor, the team is working with support from a $4.85 million grant from the U.S. Defense Advanced Research Projects Agency.

"Our team is unique," says Ma. "We are the only group using diamond."

On paper, bipolar transistors made with diamond could achieve much greater linearity and power than the silicon devices commonly used in today's electronics.

But for more than four decades, researchers have not actually been able to harness diamond's promising properties—especially in bipolar transistors.

There's a really good reason diamond doesn't hold the same luster for other research groups. The precious stone has one major shortcoming: It's rather stuck in its ways.

Bipolar transistors need two types of charge carriers to function. And to achieve those two types of charge carriers, they must contain junctions between two different types of materials: doped p-type and n-type.

Engineers add substances called "dopants" to create the p-type and n-type versions of materials, and some, like silicon, are happy to play along, readily forming both varieties.

Unfortunately, diamond is discerning. And despite more than 40 years of trying, researchers have failed to incorporate an effective n-type dopant.

Additionally, mixing p-type diamond with the n-type of a different semiconductor material, such as silicon or germanium, has long been impossible because the atoms at semiconductor junctions must align perfectly. Even the slightest mismatch between the crystalline structures of the p-type material and the n-type material will destroy its semiconducting properties.

In other words, only materials whose atoms arrange themselves into similarly spaced patterns can be combined in heteroepitaxy—and that limits which materials will work for many types of transistors, photon-sensing devices or light-emitting devices.

The difference between the atomic structures of diamond and silicon is vast. "There is a huge mismatch. One is basically in the south pole and the other is basically in the north pole," says Ma.

Ma devised an ingenious strategy to overcome that mismatch. He inserted an ultrathin intermediate layer, measuring mere atoms across, to bridge the gap between the two different semiconducting materials—without interrupting the flow of current carried by the two types of charge carriers.

That intermediary—an ultrathin oxide—would, under normal circumstances, block current between the p-type and n-type layers. But Ma leveraged a phenomenon of quantum mechanics called quantum tunneling to allow electricity to flow through the narrow oxide layer.

Voila! Using their expertise in materials fabrication, Ma and colleagues combined diamond with silicon. And while they were at it, they also combined diamond with gallium arsenide, which is currently used in the most state-of-the-art transistors.

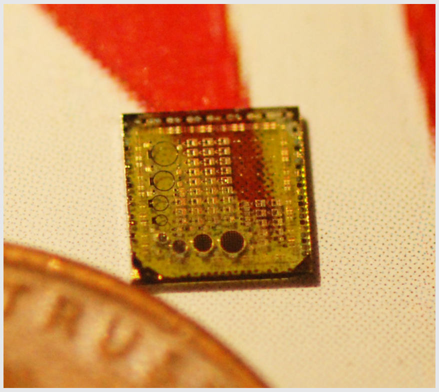
Moving forward, the team will develop diamond-based transistors, with the goal of achieving four-fold improvement on radio-frequency power density over the current best semiconductor devices. They are patenting this unique technology through the Wisconsin Alumni Research Foundation.

However, the researchers won't focus on diamonds forever: Their ultrathin oxide strategy makes it possible to match up almost any pair of p-type and n-type semiconductors—and in total, the team has created more than 10 novel combinations of materials using the approach.

In the commercial world, that could pave the way to ultra-high-performance electronic devices.

Each combination opens up new electronics or optoelectronics application fields and drastic performance improvement possibilities for LEDs, high-power communications, and many, many other devices.

"Every time you combine new materials, you find something new," says Ma.



Made from diamond, and measuring smaller than a penny, newly developed devices can transmit signals with higher dynamic ranges than any other existing technologies. *Image: Sang June Cho*

Hagness named treasurer of ECE department heads association

The Electrical and Computer Engineering Department Heads Association elected Susan Hagness, the Philip Dunham Reed Professor and ECE department chair, to its board as treasurer for the 2019-2020 academic year. Nearly 90 percent of the roughly 300 ABET-accredited ECE programs in the United States are members of the association. As a member of the board of directors, Hagness will help advance the association's mission to move the field of ECE forward while facilitating member interaction and idea exchange, as well as improving communication among department heads and practitioners within the profession, industry, government and other organizations.

Booske honored for innovative educational leadership

For his leadership in the Wisconsin Collaboratory for Enhanced Learning (WisCEL) at UW-Madison, John Booske, the Duane H. and Dorothy M. Bluemke Professor, Vilas Distinguished Achievement Professor and former ECE department chair, received the 2018 Innovative Program Award from the Electrical and Computer Engineering Department Heads Association. The award recognizes individuals or departments that create, implement and sustain innovative programs. WisCEL is a shining example of such programs. Since its launch in 2012, WisCEL has grown to an annual student enrollment of more than 5,000 students. Those students take more than 40 different courses. They are taught by 35 different instructors and 30 TAs from 30 departments at UW-Madison. WisCEL now spans five divisions offering instructional resources, technology and support in several multi-use student-centered learning environments across the UW-Madison campus. Booske received his award during the 2019 Electrical and Computer Engineering Department Heads Association annual conference on March 25 in Tucson, Arizona.

UNDERGRADUATE STUDENT NEWS

Luquant Singh, a junior from Verona, Wisconsin, majoring in applied math, engineering and physics, received a prestigious Barry Goldwater Scholarship for undergraduate excellence in the sciences. Singh began research at UW-Madison the summer after graduating from high school. He currently conducts computational plasma physics research on the Helically Symmetric eXperiment (HSX), a fusion energy device, with Professor David T. Anderson, the Jim and Anne Sorden Professor. Singh has earned authorship on national conference presentations and an in-preparation paper and serves on the design team for a new plasma physics device to be built at UW-Madison. He also attends the university on a full-tuition music scholarship for clarinet performance.

In summer 2019, Singh will conduct computational plasma physics research at the Princeton Plasma Physics Laboratory under the direction of Stuart Hudson. After graduation, he plans to pursue a PhD in plasma physics.

BEST U.S.News & WORLD REPORT RANKINGS

ECE retains high graduate program rankings

With opportunities to study under internationally renowned faculty and research staff in highly ranked programs, our graduate students are among the world's elite. They are highly sought for faculty positions at major universities and for leadership and technical roles in government and industry.

That excellence is one reason why UW-Madison graduate programs were once again ranked among the nation's best in the 2020 edition of U.S. News & World Report's "Best Graduate Schools."

This year, ECE earned two top-20 spots in the rankings with the computer engineering program at 12^{th} and electrical at 16^{th}.

U.S. News does not rank all programs each year. The rankings are based on assessments by academic peers, feedback from hiring managers, student selectivity, research expenditures, and stature of the faculty.

NELSON TANSU: EXCEPTIONALLY GRATEFUL FOR HIS WISCONSIN EXPERIENCE

As a child growing up in Indonesia during the late 1980s, Nelson Tansu (BS '98, PhD '03) always knew that his passion for science and natural curiosity would bring him to the United States for his education. His dream was to become a science professor.

Still, Tansu was truly taking a huge step into the unknown when he decided to enroll at UW-Madison.

Without the benefit of campus visits or even websites, Tansu selected his future home based solely on what he could discern from paper college catalogues and chapters in college guidebooks.

Luckily, UW-Madison stood out; what other midwestern school in a moderately sized city boasts more than a dozen Nobel laureates? Also noteworthy were the Wisconsin Idea, the world-class faculty members, the incredible student experiences, and the alumni accomplishments.

And Tansu's choice to become a Badger worked out very well indeed.

"It was one of the best decisions I have made in my life," says Tansu. Tansu received his bachelor's degree in applied mathematics, electrical engineering, and physics (AMEP)—an interdisciplinary degree between the College of Letters and Science and College of Engineering—in 1998, and then he continued to complete his PhD in electrical engineering in 2003. He is now the Daniel E. '39 and Patricia M. Smith Endowed Chair Professor in the Department of Electrical and Computer Engineering and Center for Photonics and Nanoelectronics at Lehigh University.

As a student, not only did Tansu meet his future wife, Adela Gozali Yose (BBA '03) (though the two didn't begin dating until after they had both graduated and moved to the east coast), but he also encountered an environment at UW-Madison that shapes his approach to teaching, research and mentorship to this day.

"I am a product of Wisconsin," says Tansu. "I try to bring the value of the Wisconsin experience and engineer that to my surroundings. The confidence, positive ambition, long-term vision, ethical and loyalty, and the committed and collaborative approach that I found at Wisconsin shape the ways that I handle situations in my career and life."

One key aspect of that experience was the chance to interact with world-class professors inside and out of the classroom.

Although Tansu found numerous influential mentors at UW-Madison, a few stand out in his memory, including ECE Professors Luke Mawst (his PhD advisor) and Dan Botez, CBE Professor Thomas Kuech, as well as many others in the College of Letters and Science.

"I imagined that professors would be overwhelmed, but it wasn't true," says Tansu. "Doors were always open for me to ask questions, whether about the class, career advice or life experience."

It's a philosophy that Tansu still embraces in his faculty career at Lehigh University, along with a commitment to providing the same outstanding education he received at UW-Madison.

"Students come to universities with great dreams, and it is our job as professors to grow those dreams and transform them into realities. I was fortunate to have wonderful professors and mentors at UW-Madison. It is my passion and privilege to try my best to emulate the same commitment to my students in my faculty career," he says.

Evidence of Tansu's commitment to inspiring young minds is evident in the best-selling children's book, *Nelson, the Boy who Loved to Read* (*Nelson si Kecil yang Suka Baca*, in Indonesian). The book chronicles Tansu's life story and teaches children the importance of having a strong desire to read and learn, the significance of having big dreams, and the need for having strong persistence to achieve them.

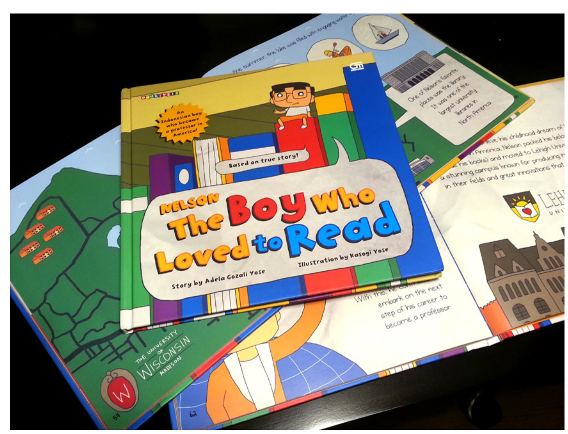
For his graduate degree, Tansu worked under the mentorship of Professor Luke Mawst, completing his PhD in 2003 and winning that year's Harold A. Peterson Best ECE Dissertation Award.

Since then, Tansu has authored more than 134 journal articles and more than 280 conference publications—earning a spot in the 2018 Clarivate Analytics highly cited researcher list. In addition, he also has 17 U.S. patents awarded. His contributions to III-V and III-nitride semiconductor research, key components of high-performance lasers and cutting-edge solid-state lighting technologies, merited him induction as a fellow of the National Academy of Inventors in 2016.

And even though Tansu's travels have taken him around the globe and he already is enjoying the fruits of a wildly successful career, he still knows there is no place on Earth that can compare to Madison, Wisconsin.

"If you can succeed at UW-Madison, you can succeed in the world," he says.

Read more: www.engr.wisc.edu/nelson-tansu-exceptionally-grateful-wisconsin-experience/



THELMA ESTRIN: FORWARD-THINKING COMPUTER SCIENTIST

One of the first people to ever apply computers in medicine was a University of Wisconsin computer engineering alumna who was born nearly a century ago.

Thelma Estrin was an early pioneer of the field of medical informatics—the now commonplace practice of applying computers to medical research and treatment. She also was something of a trailblazer for women hoping to pursue careers in the sciences.

Growing up in New York City, Thelma Austern (who took her husband Jerry's last name, Estrin, when they married in 1941) always had an aptitude for math and science, but those fields were generally off-limits for women in the years following the Great Depression.

"I was the first woman engineer I ever knew," she said in 1982, when receiving an achievement award from the Society of Women Engineers.

That was among her many firsts. In 1961, Thelma published one of the first descriptions of a system to digitize electrical impulses from the nervous system. She went on to author dozens of research papers about mapping the brain with computers during a professional career that spanned some-40 years.

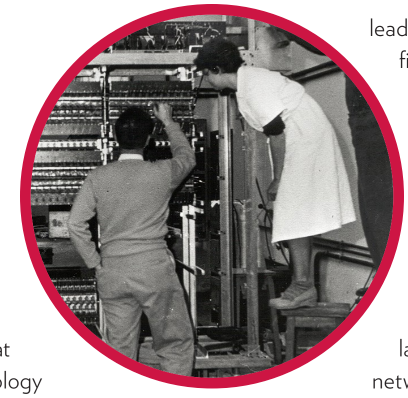
Throughout her career, and especially during the later years, Estrin was a tireless advocate for women in engineering. She knew firsthand how difficult it could be for women to get their feet in the door.

"At school, nobody took me very seriously," she said in a 1981 interview with the magazine *U.S. Woman Engineer.* "But I took myself seriously."

Estrin attributed her self-confidence to the influence of her mother, who owned and operated an automotive parts store until her marriage to Estrin's father at the age of 27. Throughout Estrin's childhood, her mother also was a community leader in their local Democratic party.

And Estrin credited her mother for teaching her that women shouldn't take a back seat. That lesson persisted, even though her mother died from cancer when Estrin was just 17.

Shortly after she and Jerry married, the United States entered World War II, and everything changed for Estrin. Factory floors emptied as men deployed overseas and women entered the workforce like never before. It was a blessing in disguise and an opportunity to put her talents to use.



Jerry enlisted in the Army Signal Corps, while Thelma took a three-month short course at Stevens Institute of Technology to become an engineer's assistant.

Toward the end of the war, Estrin and Jerry moved to San Bernadino, California, where Estrin worked as a radio technician. After Jerry was discharged, the couple moved to the Midwest, and both enrolled at the University of Wisconsin.

Even though Estrin was the first woman engineer that she herself ever knew, her skill and tenacity helped countless other women follow in her footsteps.

The couple selected the university because a dear friend also was pursuing his degree in Wisconsin.

Supported by teaching stipends, benefits from Jerry's G.I. Bill, and the sale of Estrin's mother's diamond ring, the two both completed their undergraduate and graduate degrees at Wisconsin. Estrin earned her bachelor's, master's and PhD degrees in electrical engineering in 1948, 1949 and 1951, respectively.

Although Estrin often encountered anti-Semitism and sexism from her classmates, she found a supportive mentor on campus in Professor T.J. Higgins, whose encouragement and openness spurred Estrin on. The two remained confidantes for many years.

For the next four decades, Estrin blazed a trail across the country and around the world in computer science and engineering. She and Jerry built Israel's first supercomputer, a hulking behemoth named WEIZIAC. After joining the faculty at the University of California, Los Angeles, working in its then-nascent Brain Research Institute, Estrin was lead engineer on the country's first grant for establishing a computer facility at a medical school.

Estrin became director of the Brain Research Institute's nationally renowned data processing laboratory in 1970 and later developed a computer network between UCLA and the University of California at Davis. As her career progressed, she became interested in how computers could help clinicians make better decisions and contributed to developing EMERGE, a first-of-its-kind system to guide emergency room personnel in treating chest pain.

Active in several scientific societies, Estrin was the first woman elected to the board of IEEE—the world's largest technical professional organization for technology advancement—as well as its first female vice president. Additionally, as a fellow of the American Association for the Advancement of Science, Estrin led the engineering and computer sections in 1989 and 1994, respectively.

She retired in 1991 and died in 2014.

And even though Estrin was the first woman engineer that she herself ever knew, her skill and tenacity helped countless other women follow in her footsteps.

"Refusing to be daunted by prejudice, she demonstrated through the undeniable quality of her work that talent is not tied to gender," read the citation for Estrin's honorary doctor of science degree from UW-Madison, which was awarded in 1989. "She has been a model for other women who have entered and enriched the field of engineering."

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A COMMON THREAD

Amy Wendt stitches together research and art

Professor Amy Wendt's work in the lab has led to numerous peer-reviewed publications, conference presentations and advisory reports that guide future U.S. research directions. But one product of her impressive scholarly output won't be found on her curriculum vitae or the citation index Google Scholar: Wendt is a quilter, and she sometimes uses needle and thread to stitch engineering-themed patterns into her projects.

Recently Wendt rendered an illustration of an antenna array graph onto a quilt. Ever an engineer, she took advantage of the college makerspace's computer-controlled sewing and embroidery machine to plot the data onto the quilt's fabric axes.

The quilt was a winning entry the spring 2019 biannual "Art of Science" competition at the California Institute of Technology—Wendt's alma mater. It will be on display at CalTech's art gallery in Pasadena, California, for several months.